

# **ACTS FOR DISTANCE EDUCATION IN DEVELOPING COUNTRIES**

## **First Year Interim Project Report**

November 2, 1995

FSEC CR-859-95

*Prepared for:*

**Savannah State College  
and  
NASA Lewis Research Center**

*Prepared by:*

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## ***Course Design Principles for Technology-Based Distance Education***

### **Workshop Evaluation** **November, 1995**

**Directions:** Now that you have completed this workshop, please provide information about your experience. Your answers will provide valuable information to help us improve this workshop and others like it.

**For questions 1-5, please rate the following aspects of the workshop using the scale below. Please circle the number that is most appropriate for you.**

1	2	3	4	5
----- ----- ----- -----				
Inadequate	Fair	Good	Very Good	Excellent

- |   |   |   |   |   |   |
|---|---|---|---|---|---|
| 1. Overall quality of the workshop                | 1 | 2 | 3 | 4 | 5 |
| 2. Quality of the workshop presentation           | 1 | 2 | 3 | 4 | 5 |
| 3. General organization of the course             | 1 | 2 | 3 | 4 | 5 |
| 4. Time allotted to cover workshop topics         | 1 | 2 | 3 | 4 | 5 |
| 5. Opportunities for interaction with the teacher | 1 | 2 | 3 | 4 | 5 |

6. Please rate the pacing of the course presentation. Circle the number that is most appropriate for you.

1. Very much faster than I would have liked.
2. Faster than I would have liked.
3. About right.
4. Slower than I would have liked.
5. Very much slower than I would have liked.

7. How would you rate this workshop in comparison to other workshops you have taken? Circle one number that best applies to you..

1. Superior
2. A little better
3. About the same
4. Not as good
5. Much worse

For questions 8-10, please rate the following aspects of the workshop materials using the scale below. Circle the letter that is most appropriate for you.

1	2	3	4	5
----- ----- ----- -----				
Inadequate	Below Average	Average	Above Average	Excellent

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| 8. The readability of graphics and word pictures                           | 1 | 2 | 3 | 4 | 5 |
| 9. The overall quality of the printed lesson and interactive study guide   | 1 | 2 | 3 | 4 | 5 |
| 10. The value of the practice activities in helping you learn the content. | 1 | 2 | 3 | 4 | 5 |

For questions 11-14, please rate the following aspects of the instructors using the scale below. Circle the letter that is most appropriate for you.

1	2	3	4	5
----- ----- ----- -----				
Inadequate	Below Average	Average	Above Average	Excellent

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| 11. The instructor's delivery of information                 | 1 | 2 | 3 | 4 | 5 |
| 12. The instructor's encouragement of your critical thinking | 1 | 2 | 3 | 4 | 5 |
| 13. The instructor's ability to stimulate your interest      | 1 | 2 | 3 | 4 | 5 |
| 14. The understandability and clarity of the instructor      | 1 | 2 | 3 | 4 | 5 |

For questions 15-21, please provide short answers.

15. Were the goals and objectives of this workshop made clear to you? Yes\_\_\_\_ No\_\_\_\_  
Explain:
16. Did this workshop meet your expectations? Yes\_\_\_\_ No\_\_\_\_  
Explain:
17. What did you like **most** about this workshop?
18. What did you like **least** about this workshop?
19. On the following scale, circle the number that best reflects your attitude toward attending the next faculty development workshop in this series.
1. Very favorable (I will take it).
  2. Favorable (I probably will take it).
  3. Not sure (Whether I will take it depends on the topic and other considerations).
  4. Moderately unfavorable (I probably will not take it).
  5. Unfavorable (I will not take it).
20. What would you like to learn more about in the third workshop of this series?
21. Any additional comments? (use back if necessary)

# **ACTS FOR DISTANCE EDUCATION IN DEVELOPING COUNTRIES**

**First Year Interim Project Report: September 29, 1994 through September 28, 1995**

## **Status of Tasks**

### **Task 1. Prepare report on ACTS technologies**

Efforts during year one of the project have been directed towards research and review of documents, equipment, and methods of instructional design, in order to determine the appropriateness of ACTS technologies for the proposed educational program.

- A literature search was conducted and over 30 identified documents have been collected and are under review (see Appendix A).
- A paper entitled, *A Cost Comparison of Alternative Approaches to Two-Way Interactive Distance Learning in Developing Countries* was prepared to provide a cost comparison among three different levels of interactive distance learning systems for developing countries. This paper was presented at the ACTS Results Conference held in Cleveland, Ohio, September 11-13, 1995, and was included in the proceedings (see Appendix B).
- Preferred configurations for origination/receive sites were identified (see Appendix C). The preferred origination site will allow instructors to deliver courses using a PC-based, desktop video-conferencing system from their office and share software with students at the receive site.

### **Task 2. Prepare report on ACTS for developing countries**

- Criteria were established for identifying possible participating countries.
- Twenty-eight potential locations for hub sites were identified based on criteria and formal meetings with U.S. AID, U.S. ECRE, RETI, IEA, Georgetown University, and representatives of developing countries.
- A white paper was prepared entitled, *Rural Electrification Environmental Remediation and Economic Development in Latin America and Africa* (see Appendix D).

### **Task 3. Prepare course manuals**

- Significant additions and revisions have been made to the comprehensive course reference manual which is still under development.
- Formats for course manuals were reviewed

- Specifications for desktop video systems were reviewed and procurement is imminent.

#### **Task 4. Prepare computer and other courseware**

- Thirty hours of videotape have been produced in conjunction with Brevard Community College (see Appendix E).
- Computer slide shows for all segments of the Photovoltaic System Design course have been developed.

#### **Task 5. Deliver distance education from FSEC to SSC**

- The workshop planned for August 1995 was cancelled by Savannah State College. (No firm date has yet been established for delivering the 30-hour course to Savannah State College.)

#### **Task 6. Evaluate distance learning experience**

- A research agenda that addresses many learning experience issues was developed (see Appendix F). (This is primarily a Savannah State College task.)

#### **Task 7. Demonstrate program effectiveness (This is primarily a Savannah State College task.)**

#### **Task 8. Perform a SCADA experiment**

- Orion Energy was contacted concerning future participation in this task.

#### **Task 9. Evaluate program sustainability**

- Several meetings were held with AT&T to discuss future collaboration and program sustainability.

#### **Task 10. Report progress**

- Project meetings were conducted at FSEC and UCF to review progress (October 17, 1994, February 6, 1995, March 20-22, 1995).
- Attended a NASA-sponsored HBCU meeting and presented poster paper at the Ohio Aerospace Institute, April 1995.
- Attended the ACTS Results Conference and presented cost paper, September 11-13, 1995.

## Appendix A

Literature Search: Review Documents

Author  
Title Education a Distancia en America Latina  
Institution  
Pub Date 92  
Publisher  
Note 107p

Author  
Title Impact Assessment and Forecasts of Information & Telecommunications... Vol. III.  
Institution Commission of the European Communities, Brussels (Belgium).  
Pub Date May 90  
Publisher  
Note 44p.

Author  
Title Software development course beamed to 13 Mexican Technical Institute campuses.  
Institution  
Pub Date Spring 95  
Publisher Carnegie Mellon Magazine  
Note p8

Author Bauer, Jeffrey W.; Rezabek, Landra L.  
Title The Effects of Two-Way Visual Contact or Student Verbal Interaction During Teleconferenced Instruction.  
Institution  
Pub Date Feb. 92  
Publisher  
Note 14p

Author Blinn, Charles, Flack, Jan & Bates, Peter  
Title Developing Telecommunication Linkages for Microcomputer-Aided Instruction  
TDC Research Report No. 1.  
Institution Minnesota Extension Service. University of Minnesota  
Pub Date January 1989  
Publisher  
Note 12p

Author Bradley, Case Julia  
Title A Quick Guide to the Internet  
Institution Mt. San Antonio College  
Pub Date 95  
Publisher Wadsworth Publishing Company A Division of International Thomson Publishing Inc.  
Note 109p.

Author Bunting, Larry  
Title Distance Learning via Satellite Begins with Analysis of the Users.  
Institution  
Pub Date Feb. 90  
Publisher  
Note 6p. Proceedings of Selected Paper Presentations at the Convention of the Association for Educational Communications and Technology;

Author Chacon, Fabio  
Title Taxonomy of Computer Media in Distance Education  
Institution  
Pub Date Feb. 92  
Publisher Open Learning  
Note p12-27

Author Chick, John  
Title Building for the Future  
Institution  
Pub Date 90  
Publisher  
Note

Author Chute, Alan  
Title Research Teletraining: Student Acceptance.  
Institution  
Pub Date Jan 86  
Publisher  
Note 13p

Author Chute, Alan; Hancock, Burton & Balthazar, Lee  
Title Distance Education Futures: Information Needs and Technology Options.  
Institution  
Pub Date November/December 1991  
Publisher Performance & Instruction  
Note 6p

Author Chute, Alan G.; Shatzer, Linda S.  
Title Designing for International Teletraining.  
Institution  
Pub Date May 89  
Publisher  
Note 7p

Author Chute, Alan; Thompson, Dianne, & Starin, Harvey.  
Title It's Time to Change the Way We Train!



Institution	
Pub Date	
Publisher	
Note	5p
Author	Daniel, J. S.
Title	Distance Education and Developing Countries.
Institution	The Open University United Kingdom
Pub Date	90
Publisher	Keynote Address World Congress of the International Council for Distance Education (15th, Caracas, Venezuela, November 4-10, 1990).
Note	10p
Author	DeLoughry, Thomas J.
Title	in the Structure of the Internet
Institution	
Pub Date	January 20, 1995
Publisher	Chronicle of Higher Education
Note	p19
Author	Doyle, T.C.
Title	the Price s (Almost) Right
Institution	
Pub Date	March 1,1995
Publisher	VARBusiness
Note	p42
Author	Fredrickson, Scott
Title	Audiographics for Distance Education: An Alternative Technology.
Institution	
Pub Date	Mar. 90
Publisher	
Note	6p
Author	Hershfield, Allan F.
Title	Distance Education: The Promise and the Confusion!
Institution	
Pub Date	Jul 86
Publisher	
Note	15p.
Author	Hodgen, Doris
Title	A Distance Education Approach to Continuing Legal Education in South Dakota Using Public Television Overnight Service.

Institution  
Pub Date May 90  
Publisher  
Note 13p.

Author Jacobson, Robert L.  
Title The Virtual College  
Institution  
Pub Date January 27, 1995  
Publisher The Chronicle of Higher Education  
Note 2p

Author Jegede, Olugbemiro  
Title A Distance Education Research Agenda: A Survey of Expert Opinions from Developed and Developing Countries.  
Institution  
Pub Date Nov. 92  
Publisher  
Note 16p.

Author John, Magnus  
Title Africa: A Survey of Distance Education, 1991. New Papers on Higher Education: Studies and Research 4.  
Institution International Center for Distance Learning-of the United Nations Uni., Milton Keynes (England).; International Council for Distance Education.; United Nations Educational, Scientific, and Cultural Organization, Paris (France).  
Pub Date 91  
Note 174p.; Co-ordinator: Keith Harry.

Author Maher, Thomas G.  
Title Television-Centered, Instructional Delivery Systems: Costs and Case Studies. A Review of Research.  
Institution  
Pub Date 1 Jun 82  
Publisher  
Note 20p.

Author McGreal, Rory; And Others  
Title Recommendations on Distance Education to the Northern Education Project of the Ministry of Education of the Government of Ontario. Submitted by the Distance Education Secondary School Committee of Northern Ontario.  
Institution  
Pub Date 16 Nov. 92  
Publisher  
Note 11p.

Author McMurry, James G.: Trott, James W.  
Title Telelearning Offers New Alternatives for T&I Delivery Systems.  
Institution  
Pub Date 5 Dec. 87  
Publisher  
Note 13p.

Author Mwakilosa, Amos  
Title Distance Education for Health Personnel: New Strategies.  
Pub Date 92  
Publisher World Health Organization  
Note 32p.

Author Norman, Douglas  
Title Interactive Radio as a Component of Distance Education in Third World Countries.  
Institution Pembroke State University  
A Paper Presented At The National Third World Studies Conference: Omaha,  
Nebraska, October, 1993  
Pub Date 93  
Publisher  
Note 10p.

Author Roberts, Judy  
Title Development of a Distance Education Network in the OECS.  
Institution Commonwealth of learning.  
Pub Date June 92  
Publisher  
Note 41p.

Author Robertson, William D.  
Title Audio Teleconferencing: Using Old Technology to Reduce Course Delivery Costs  
and Improve Services to Rural Students.  
Institution  
Pub Date 29 May 84  
Publisher  
Note 13p.

Author Suen, Hoi-K  
Title American Journal of Distance Education. "Analytic Considerations I Distance  
Education Research."  
Institution  
Pub Date 93; V7(3)  
Publisher  
Note 61-69p.

Author Wall, Milan  
Title Information Technologies: Alternative Delivery Systems for Rural Schools.  
Institution Wall & Associates, Lincoln, NE.  
Pub Date 20 Nov. 85  
Publisher  
Note 39p.

## Appendix B

# A COST COMPARISON OF ALTERNATIVE APPROACHES TO TWO-WAY INTERACTIVE DISTANCE LEARNING IN DEVELOPING COUNTRIES

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Gerard G. Ventre<sup>4</sup>, and Patrick J. Moskal<sup>1</sup>

## INTRODUCTION

### Purpose of the Report

The purpose of this report is to provide a cost comparison among three different levels of two-way interactive distance learning systems for developing countries. Comparisons are made in the costs of the distance learning hardware systems, the costs of using various terrestrial and satellite communication links, and the costs of designing instruction for distance learning using a two-way interactive distance learning system.

As used in this paper, two-way interactive distance learning means that communication between students and teachers who are physically separated is possible through both audio and video channels. In other words, two-way audio and video distance learning allows students and teachers to interact in real time. The technical importance of this definition is that two-way interactive audio and video transmissions require high communications bandwidths.

### Background

Within the past year, NASA Lewis Research Center entered into a cooperative agreement with Savannah State College (SCC) and the Florida Solar Energy Center (FSEC) to conduct a project called "ACTS for Distance Education in Developing Countries." As part of this project, FSEC is developing a 30-hour course in photovoltaic system design that will be used in a variety of experiments using the Advanced Communications Technology Satellite (ACTS). A primary goal of the project is to develop an instructional design and delivery model that can be used for other education and training programs.

This project is directed toward meeting basic human needs in developing countries. Based on data from FSEC, over two-thirds of the world's population does not have access to utility-generated electricity, and less than 25% receive electricity in a reliable and predictable manner. Photovoltaic-generated electricity represents a distributed source of energy that could significantly improve the quality of life in much of the world. Because of its simplicity and reliability, the world demand for photovoltaic systems is increasing. However, to significantly impact the problem, the energy infrastructure within the developing countries needs to be enhanced. Energy education and training is a key ingredient in infrastructure enhancement.

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<sup>3</sup> Global Datalink Incorporated (GDI), Orlando, Florida

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Presently, many of the international training efforts in energy are through U.S. Department of Energy programs. The U.S. photovoltaic industry is also actively involved in training and there is considerable competition with Europe and Japan for international markets. Over two-thirds of the world market is in developing countries. Because of the poor economic conditions in the developing countries, much of the funding for programs and equipment comes from multilateral organizations.

The Florida Solar Energy Center has been involved in energy education and training for over fifteen years. Typical programs include workshops or short courses of several days duration. Sometimes these programs are offered at FSEC's facilities and sometimes they involve travel to the developing countries in order to deliver the courses. Unfortunately, the influence of these programs is short-term in most cases. A permanent communications link with the appropriate institutions in these countries will provide significant help to sustain the momentum necessary for long-term progress.

One of the objectives of this NASA-sponsored project was to develop new and better energy education programs that take advantage of advances in telecommunications and computer technology. The combination of desktop video systems and the sharing of computer applications software is of special interest. Considerable research will be performed to evaluate the effectiveness of these technologies as part of this project. The design of the distance learning origination and receive sites discussed in this paper were influenced by the educational community's growing interest in distance education.

A project goal is to develop an instructional systems design model and an instructional delivery scenario that represents the best tradeoff between costs, outreach, instructional effectiveness and sustainability. This paper deals primarily with an assessment of the costs involved for a number of alternative approaches to two-way interactive distance learning.

Methodology. The following approach was used to develop comparative costs for two-way interactive distance education in developing countries:

- Representative target locations for receive sites were chosen. The originating site was assumed to be Cocoa, Florida, where FSEC is located.
- A range of course development costs were determined. Two hypothetical courses were used in the analysis: a short eight-hour course and a longer 80-hour course.
- The cost of obtaining equipment for three alternative two-way interactive distance learning system configurations was determined. The types of system configurations ranged from a PC-based, desktop video-conferencing system, that allows instructors to originate instruction from their offices using desktop video and shared software, to a high cost system that uses an electronic classroom. Each system configuration allows for the use of some form of two-way interactive video and shared application software.
- A range of costs for both satellite and terrestrial communications were investigated.
- The costs of equipment and operation of the alternative configurations for the origination and receive sites were determined.

- A range of costs for several alternative delivery scenarios (i.e., a mix of live-interactive; asynchronous interactive; use of video tapes) was determined.
- A preferred delivery scenario including cost estimates was developed.

**Target Locations.** Savannah State College, through their Center for Advanced Water Technology and Energy Systems, has targeted the continent of Africa for its training efforts. The Florida Solar Energy Center is primarily interested in Latin America. Within both these areas, FSEC has identified major needs in energy and environmental infrastructure development, clean water supply, health care, agricultural sciences, and small business development. To address the energy education needs, criteria for selecting the receive sites were based on energy resources and needs, existing education and training infrastructure, in-country supporting institutions, and prospects for funding. A total of 27 potential sites were identified based on these criteria. For this paper, five representative receive sites were chosen: a) Cairo, Egypt; b) Johannesburg, South Africa; c) Mexico City, Mexico; d) Quito, Ecuador; and e) Santiago, Chile.

## HARDWARE COSTS

### Purpose

The purpose of this section is to describe three two-way interactive distance learning systems and their associated costs. Each system configuration is explained in terms of: a) the hardware found at the network site where the instruction originates (origination site) and b) the hardware found at the network site where the instruction is received (receive sites).

### Types of System Configuration

The three configurations were defined in terms of their instructional capabilities and the overall cost of the system. All three system configurations provide similar opportunities for two-way interaction and all configurations provide for motion video, shared software, and still graphics. The higher cost systems generally provide greater video fidelity and have the ability to support an increased variety of instructional activities (for example, to support computer-based collaborative learning activities using a local area network). The system configurations analyzed here are categorized as the: a) "desktop video system," b) "group video system," and c) the "electronic classroom system." The figures used in this analysis were obtained from written quotes from distance learning hardware vendors.<sup>1</sup> Each of these systems were selected because in terms of both cost and performance they were representative of typical two-way distance learning systems that are available in each of the three price ranges.

<sup>1</sup> These costs were obtained from proprietary vendor quotes and the sources must remain anonymous



## System One: Desktop Video

Concept. The basic component of this system is a personal computer (PC)-based desktop video conferencing system. This system allows for two-way audio and video communication among eight sites (seven receive sites and one origination site). This system has the capability to provide shared software, and electronic mail. The origination site equipment allows instructors to originate two-way interactive distance learning courses from their offices. This eliminates the need to use special facilities for originating distance learning, such as a television studio.

In addition to the PCs, the desktop video system has video slate annotators that allow instructors and students to write or draw on the PC screen and a document camera that allows all of the network sites to view paper documents and three dimensional objects.

Origination site. The origination site consists of a single desktop video system and four cameras. A single stationary camera is mounted on top of the computer monitor. A pan/tilt/zoom camera provides the instructor with the ability to "zoom in" to capture details and gestures and to "zoom out" to provide a wide angle view of the instruction. The third camera is a tripod mounted camcorder that provides a third angle of viewing to capture actions such as writing on a board or performing a physical activity. The origination site is also equipped with a commercial off-the-shelf (COTS) video cassette recorder (VCR) that provides the instructor with the capability to include pre-recorded video tapes in the instruction. The document camera provides a means for switching video inputs between the four cameras and the VCR.

Receive sites. The seven receive sites also consist of a single desktop video system with a stationary camera mounted on the PC and a tripod mounted camcorder. The receive sites also have a video slate annotator, a document camera and a VCR. The VCR provides the receive sites with a means to record instruction for make-up classes and remediation. Instruction is viewed on two 32-inch color monitors. However, the monitors display the motion video in a small window. This means that the video fidelity and the amount of detail that can be shown are more limited than in the other two systems.

Some types of desktop video conferencing systems requires the use of ISDN communications. Desktop video conferencing systems that use standard telephone lines or Internet connections were considered as candidates for the desktop video system configuration. However, the current video fidelity of these non-ISDN systems is substantially lower than the system used in this comparison. Investigations into the availability of ISDN services in the target countries has revealed that ISDN does not yet exist in these countries. ISDN capability could be obtained in several ways. These methods will be outlined in the section of the paper that deals with communications.

A list of the system components and a cost approximation for the origination site, the remote sites, and the total system is provided in Table 1. A diagram of the origination site and a receive site is provided in Figures 1 and 2 respectively.

**Table I**

**Desktop Video System**

<b>Origination Site (1)</b>	
<b>Desktop video board Kit -</b>	
Two video boards (2) with NTSC Out	
200 CCD Color Camera and cables	
Application Software	
ISDN Telephone	
ISDN-BRI Network Interface	
<b>Installation</b>	
<b>PC w/Pentium 120 Mhz CPU</b>	
<b>Installation</b>	
<b>Uninterrupted Power Supply</b>	
<b>Document Camera</b>	
<b>Digitizing tablet/drawing board</b>	
<b>Camera (PTZ)</b>	
<b>Camcorder w/tripod</b>	
<b>COTS VCR</b>	
<b>17" ESVG A Monitor</b>	
<b>Approximate Cost of Origination Site</b>	<b>\$18,000.00</b>
<b>Receive Site (7)</b>	
<b>Video board kit -</b>	
Video boards (2) with NTSC Out	
CCD Color Camera and cables	
Application Software	
ISDN Telephone	
ISDN-BRI Network Interface	
<b>Installation</b>	
<b>PC w/Pentium 120 Mhz CPU</b>	
<b>Installation</b>	
<b>Uninterrupted Power Supply</b>	
<b>Document Camera</b>	
<b>Digitizing tablet/drawing board</b>	
<b>Dual 32" Inch Monitors</b>	
<b>COTS VCR</b>	
<b>Camcorder w/Tripod</b>	
<b>Total Each Receive Site</b>	<b>\$17,300.00</b>
	<b><u>      x 7</u></b>
<b>Total All Receive Sites</b>	<b>\$121,100.00</b>
<b>Add Origination Site</b>	<b><u>\$18,000.00</u></b>
<b>TOTAL SYSTEM</b>	<b>\$139,100.00</b>

1. IBM/PC Network Computer
2. Telephone
3. Microphones
4. VCR
5. Camcorder w/ tripod
6. Pan/tilt/zoom camera
7. Auto Focus Camera
8. ELMO - Graphics Stand



Figure 1. Desktop Video System Origination Site

1. IBM/PC Network Computer
2. Telephone
3. Microphones
4. VCR
5. Camcorder w/ tripod
6. Auto Focus Camera
7. ELMO - Graphics Stand

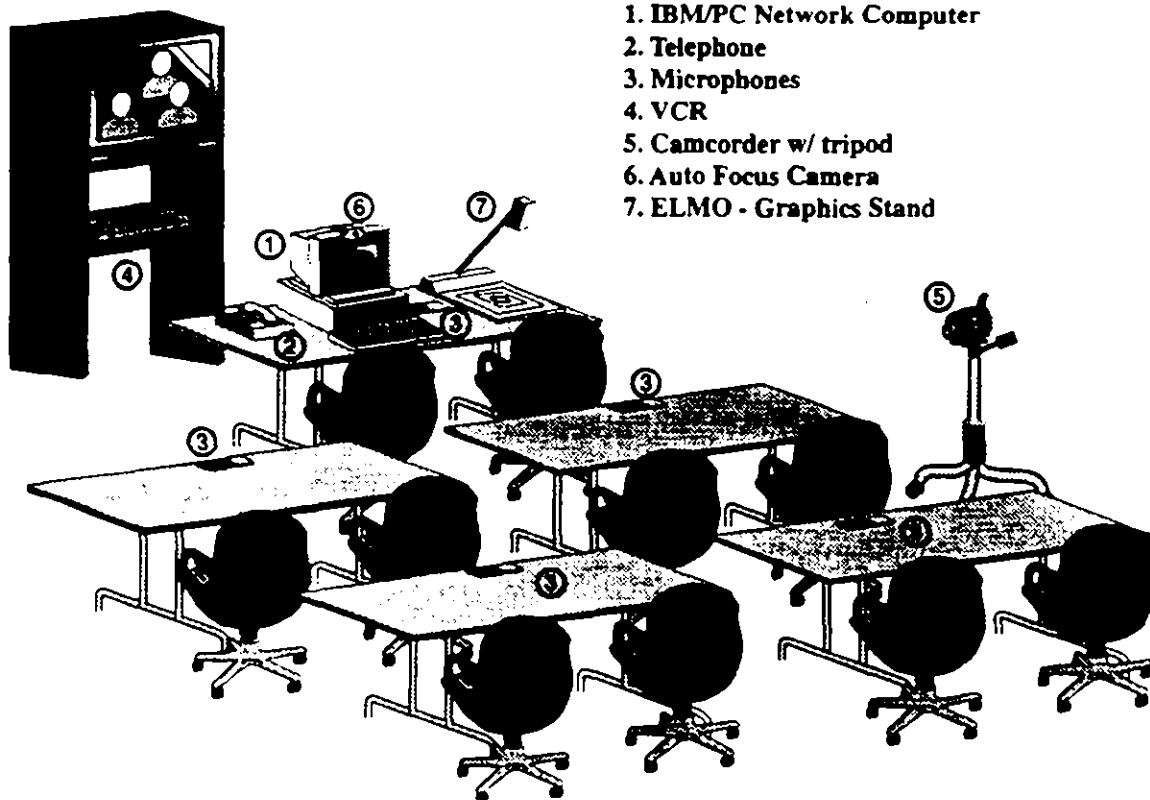


Figure 2 Desktop Video System Receive Site

## System Two: Group Video

Concept. The group video distance learning system was designed to provide two-way interactive instruction with higher video fidelity levels than the desktop video system. The group video system is composed of a room-sized, group video conferencing system. The system also consists of one origination and seven receive sites. Compared to the desktop video system, the group video system provides improved video fidelity and the video image in this system is viewed full screen rather than in a small video window. Although the room-sized video conferencing systems requires more space than the desktop based PC system used in the desktop video configuration, it still does not require extensive modification of existing facilities in order to conduct distance learning.

Origination site. The origination site consists of the room-sized group video conferencing suite that uses a 35-inch monitor and a pan/tilt/zoom and autofocus camera. A tripod mounted camcorder provides the instructor with the ability to use an additional camera angle.

A 120 Mhz, Pentium-based PC is used to provide still and motion computer graphics to enhance the instruction. This requires the use of a scan rate converter to synchronize the screen scanning rate of the computer to the National Television Standard Committee (NTSC) scanning rate of the 35-inch video monitor. The origination site is also equipped with a document camera, a COTS VCR, and a digitized writing tablet.

Receive sites. Each receive sites consists of a room-sized group video conferencing suite with dual 35-inch monitors and a 120 Mhz, Pentium-based PC. This PC provides the students with access to shared software, electronic mail (e-mail) and other ancillary information services. A COTS VCR gives each remote site the ability to record instruction for make-up classes and remediation. Each receive site must also use a scan rate converter to process the video signal from the PC so that it can be displayed on the 35-inch video monitors. A camcorder mounted on a tripod provides a second video input for the receive site so that students can demonstrate physical activities. A video slate annotator provides each receive site with the ability to draw on the computer screen.

An itemized cost breakdown for the group video origination site, the remote sites, and the total system is provided in Table II. A diagram of the origination site and a receive site is provided in Figures 3 and 4, respectively.

**Table II**

**Group Video System**

<b>Origination Site (1)</b>	
<b>Room-sized group video suite</b>	
Equipment cabinet	
Full duplex audio and echo cancellation	
SG3 and Px64 (H.320) Compression	
One CCD pan/tilt/zoom and autofocus camera	
Picture-in-picture capability	
Data port access via RS-232C up to 19.2 Kbps	
Transmission speeds 56-768 Kbps	
Dual V.35, RS-449, X.21, or V.25 network interface	
<b>PC w/Pentium 120 Mhz CPU</b>	
<b>Remote Camera - Pan/Tilt/Zoom</b>	
<b>Uninterrupted Power Supply</b>	
<b>Scan Rate Converter</b>	
<b>Camcorder w/tripod</b>	
<b>Document Camera</b>	
<b>COTS Video Cassette Recorder</b>	
<b>Digitizing tablet/drawing board</b>	
<b>Approximate Cost of Origination Site</b>	<b>\$64,000.00</b>

<b>Receive Site (7)</b>	
<b>Room-sized group video suite</b>	
(Same configuration as origination site)	
<b>PC w/Pentium 120 Mhz CPU</b>	
<b>Dual 35" Monitors</b>	
<b>Uninterrupted Power Supply</b>	
<b>COTS Video Cassette Recorder</b>	
<b>Document Camera</b>	
<b>Digitizing tablet/drawing board</b>	
<b>Camcorder w/Tripod</b>	
<b>Scan Rate Converter</b>	
<b>Approximate Cost of Each Receive Site</b>	<b>\$71,000.00</b>
	<b><u>      x 7      </u></b>
<b>Total All Receive Sites</b>	<b>\$497,000.00</b>
<b>Add Origination Site</b>	<b><u>\$64,000.00</u></b>
<b>APPROXIMATE TOTAL SYSTEM COST</b>	<b>\$561,000.00</b>

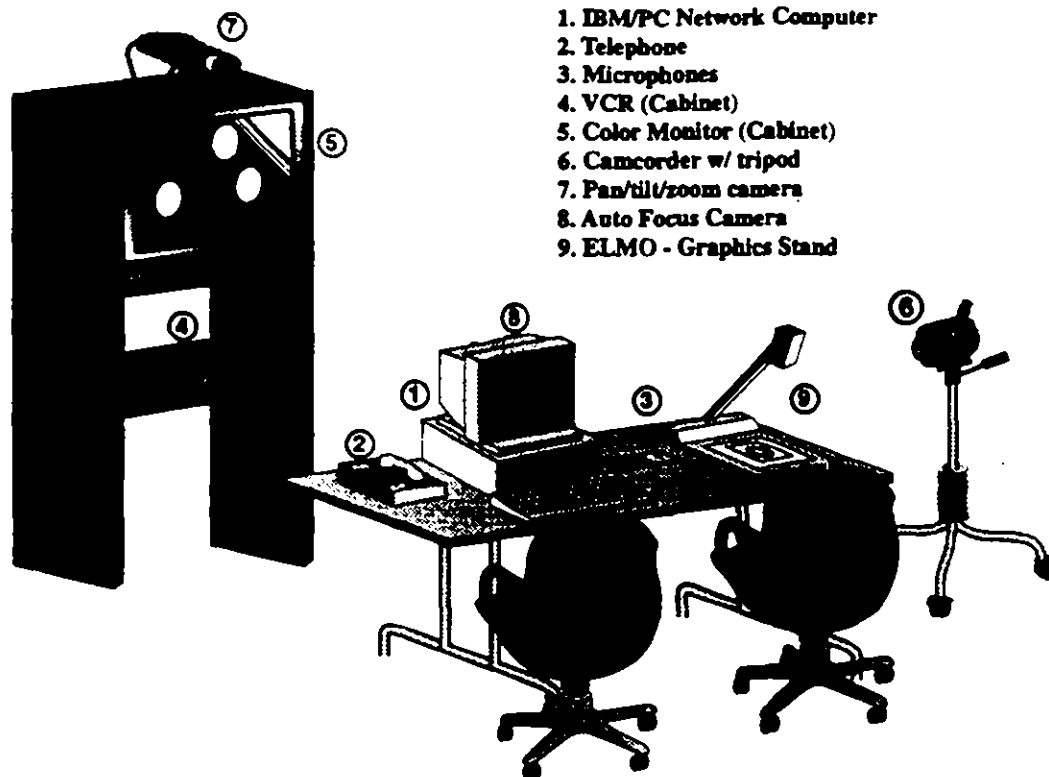


Figure 3. Group Video System Origination Site

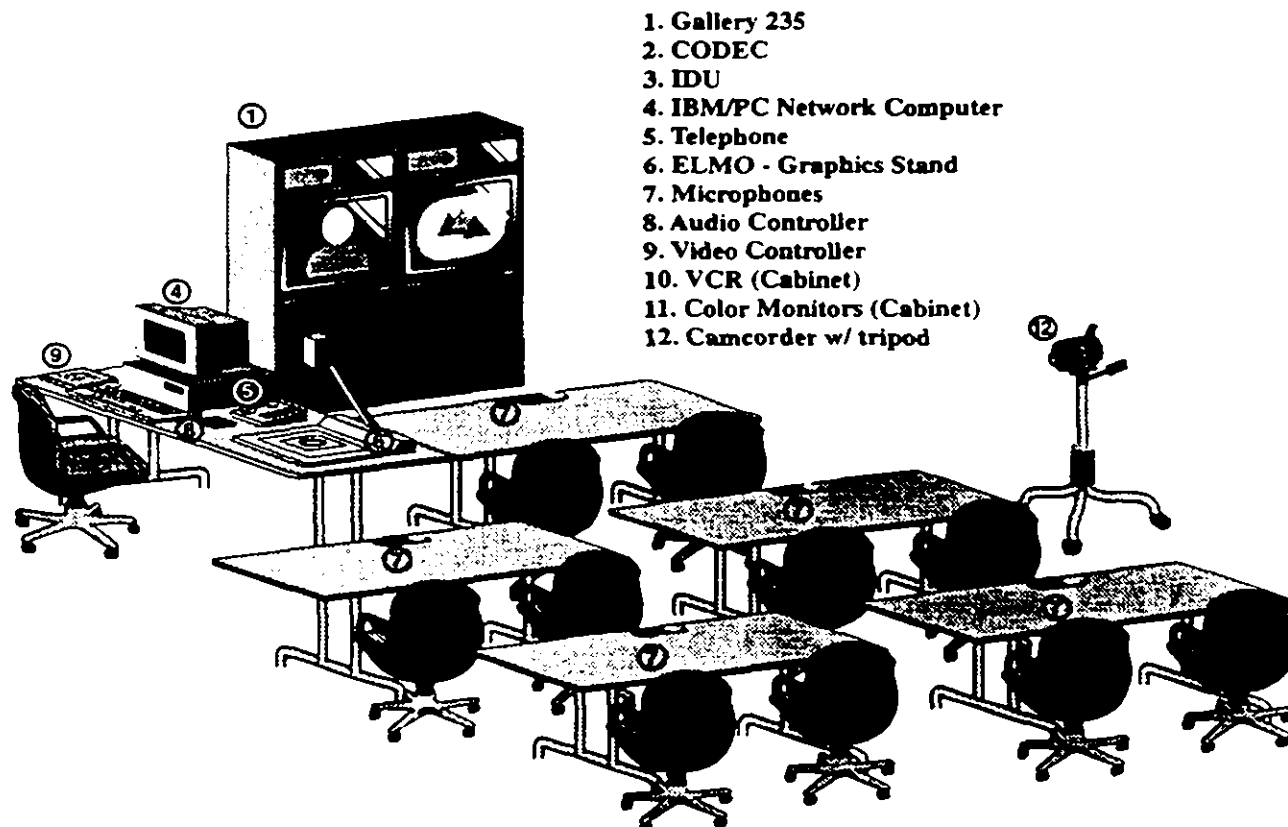


Figure 4. Group Video System Receive Site

### System Three: Electronic Classroom

**Concept.** The purpose of the electronic classroom system is twofold: (a) to give each site an equal capability to receive or originate instruction and (b) to afford greater flexibility in conduct local collaborative learning activities at each receive site. In the electronic classroom system, all sites are identically configured, that is, receive sites and origination sites have the same suite of equipment. This type of configuration allows each of the participating locations to share courses between them.

Unlike the desktop and group video configurations, the electronic classroom system provides each learning site with an EtherNet based computer network that students can use for remediation, collaborative learning exercises, or individual computer-based instruction. The electronic classroom system may require some modification of existing facilities in order to conduct distance learning.

**Instructor station.** Each of the sites in the high cost system consists of a room-sized group video conferencing suite without the television monitors that are found in the group video conferencing system. The video images are provided by a high resolution (640x480) video projector that projects the image on a screen at the front of the room.

An instructor station located at the front of the room is equipped with a Pentium-based PC that gives the instructor the ability to show computer graphics and also provides access to e-mail. The instructor station also includes a COTS VCR, a digital writing tablet and drawing board, and a document camera. The document camera also provides switching between the various video and computer inputs. A small program monitor allows the instructor to preview slides and materials or to see the signal that is being sent out over the network.

An auto-focus camera mounted on a stand with an electric motor provides the instructor with the ability to pan/tilt and zoom from the instructor station. An infrared remote control device allows the instructor to move about the classroom and have the camera automatically follow him or her.

**Learner stations.** In addition to the room-sized group video conferring suite at each site, each electronic classroom system site also provides 16 learner computer stations. Each station is equipped with a 120 Mhz. Pentium-based PC. The PCs are networked together in a local area network (LAN) using EtherNet protocols. This network provides the means for collaborative learning and sharing software at each site and between sites as well. This network can also provide access to e-mail and other networked information sources that are available on the Internet.

Table III gives a cost breakdown for the high cost system. The costs are broken out by instructor station and student station. A picture of an electronic classroom site is shown in Figure 5. Only one figure is used because both the origination and receive sites are identically configured.

**Table III**

**High Cost System**

**Teaching Station**

**Room-sized group video suite**

Equipment cabinet  
Full duplex audio and echo cancellation  
SG3 and Px64 (H.320) Compression  
One CCD pan/tilt/zoom and autofocus camera  
Picture-in-picture capability  
Data port access via RS-232C up to 19.2 Kbps  
Transmission speeds 56-768 Kbps  
Dual V.35, RS-449, X.21, or V.25 network interface

640x480 Projector

PC w/Pentium 120 Mhz CPU

CameraMan XLX Camera Mount

Document Camera

COTS Video Cassette Recorder

Digitizing tablet/drawing board

Uninterrupted Power Supply

Program Monitor

Teacher Station Total

**\$70,000.00**

**Learner Stations**

PC Pentium 120 Mhz CPU (16)

EtherNet Connector Cards (16)

Network Hub

Total Learner Station Costs

**\$50,000.00**

Teacher Station Costs

**\$70,000.00**

Total Cost Per Receive Site

**\$120,000.00**

**x8**

Total Cost All Sites

**\$960,000.00**





**Figure 5. Electronic Classroom System**

#### Summary of Hardware Costs

Three two-way interactive distance learning systems and their associated costs were presented in terms of both hardware requirements and instructional capabilities. The desktop video system consists of a PC-based desktop video conferencing system that uses a low-cost origination site, such as an instructors office or a small conference room. The group video system is a room-sized group video conferencing system that provides a higher level of video fidelity than the desktop video system. The electronic classroom system is also a group video conferencing system, but it is combined with a 640x480 resolution video projector and a LAN consisting of 16 PCs. In the electronic classroom system configuration, all of the sites are identically configured and any site can act as the origination site

Table IV provides a summary of the costs for the origination site, the receive sites, and the total network cost for each of the three configurations.

**Table IV**

	Origination Site	Receive Site	x 7 Receive Sites	Total System Cost
Desktop Video	\$18,000.00	\$17,300.00	\$121,100.00	\$139,100.00
Group Video	\$64,000.00	\$71,000.00	497,000.00	\$561,000.00
Electronic Classroom	*\$120,000.00	*\$120,000.00	\$840,000.00	\$960,000.00

\*All sites are identically configured

## COMMUNICATION COSTS

Two primary options exist for communication links for two-way interactive distance education. These are terrestrial digital lines and satellite communications links. Terrestrial digital lines include T1, fractional T1, ISDN, frame relay, etc., while satellite links include commercial stationary or portable earth stations. A third option exists for communication links and that is a combination of terrestrial and satellite links.

In order to provide cost data for these communication options in developing countries, a comparison of the following variables were included in the cost analysis:

- bandwidth requirements related to each of the three hardware systems
- duration of use of each system, e.g., number of hours per week
- local availability of the digital communication links and the existing infrastructure based on the location of the receiving sites
- the equipment (such as ground stations) required for each system and the communications regulations regarding the use of the equipment
- Installation and maintenance support required for each communication link

### Bandwidth Requirements

The Desktop Video system requires a bandwidth of at least 128 Kbps (2 B-Channel ISDN). The Group Video system and the Electronic Classroom require a higher bandwidth of 384 Kbps up to 1.566 Mbps (T1). Either terrestrial lines or satellite links could carry the bandwidth requirements for all three of the hardware systems. ISDN, however, is only useable for the desktop video system

### Duration of Two-Way Interactivity

Both satellite and terrestrial communication time is charged by some increment of time (e.g., per minute, per hour), unless it is taken in bulk, such as on a monthly basis. Therefore, the amount of time spent using a communication link will affect the cost. For example, a 15-hour course could be presented in the following ways:

- all 15 hours presented live
- of the course presented live; 1/3 presented by video tapes that are mailed to each site
- of the course presented live; 2/3 presented by videotapes that are mailed to each site
- all 15 hours presented via video tapes with no live instruction

This illustration of delivery options is only one of a number of possibilities. The point is that the more of any communication link that is used, the more it costs, unless it is leased on a monthly basis for a number of applications of which distance learning is only one.

### Location and Availability of Communication Links

High bandwidth terrestrial digital communication lines in developing countries are virtually non-existent. In addition, the terrestrial lines between developing countries and developed countries (such as the United States, where distance learning courses might originate) are also virtually non-existent. Most major telecommunications companies (such as AT&T, MCI, Sprint) do not

provide any high bandwidth digital lines to the five representative locations used in this report. Going through an intermediate country will complicate the logistics issue, which will result in increased cost and chances for failure (Global Datalink, 1994). Therefore, the option of using terrestrial links does not exist.

On the other hand, satellite communication links between developing countries and developed countries presently exist for some locations, specifically large cities. However, even for countries where these earth stations do not exist, the satellite communication links could still be established using the modular VSAT solution. Between the modularity of the VSAT technology and the possibility of providing interactively over the Desktop Video system solution, students and teachers from around the world can interact.

### **Equipment Requirements**

Because digital communications between developed and underdeveloped countries cannot be achieved using terrestrial lines, satellite links are the only option left. This option can also be achieved using existing earth stations in the different countries. However, for the sake of finding a solution that could be applied to any country of interest, the use of a standard, modular VSAT technology can be interfaced with each of the hardware system configurations described: desktop video system, group video system and the electronic classroom.

The equipment that is needed to achieve this solution is similar to the equipment that would be used if a terrestrial line solution was chosen except for the up-link/down link converter and antenna. The addition of this equipment (converter and antenna) will increase the cost per system location by approximately \$70,000. However, this represents a cost savings when compared to the costs of interfacing between two different communications protocols (e.g., frame relay, X.25, etc.).

This solution might limit the communication bandwidth to 128 Kbps but this would allow a sufficient bandwidth for conducting two-way interactive distance learning. As compression techniques and equipment continue to become more advanced, higher bandwidths will become available.

Commercial satellites require expensive earth stations, but they are available. However, a problem that arises with commercial satellites is that higher bidders for satellite time can bump lower bidders on short notice. Additionally, these earth stations may be tightly controlled by the local government.

### **Installation and Maintenance Support Requirements**

In addition to the distance learning system configurations, communications equipment to link the origination and receive sites must be installed and maintained. The installation and on-site technical support for a modular and standardized system is likely to be easier than interfacing equipment supplied by different vendors.

The video telecommunications terminal will be designed and assembled using commercial off the shelf equipment that will be tested and operated in the United States before it is shipped abroad. A methodology will be applied in the design and development of the system:

- Procedures will be developed to facilitate the assembly of various equipment.
- Test manuals and results expectations will be written and translated to different languages to facilitate on-site diagnostics.
- Back-up equipment will be purchased in case of modular failures.
- technical support will be available and reachable by phone, Internet, or fax if needed.

These types of arrangements will reduce delay time during course delivery in case of a technical problem.

### Cost Analysis

While the original intent of this paper was to provide the cost differences between terrestrial and satellite communication links, an analysis of the variables that influence these costs forced the elimination of terrestrial links. The fact that developing countries in general (and specifically the five locations selected for this report), do not have terrestrial communication links with sufficient bandwidth available, means that terrestrial options are not a viable solution.

Commercial satellite earth stations exist in limited supply in most developing countries. For example, the country of Ecuador has 14 ground stations, whereas a city the size of Orlando, Florida may have as many as five or more ground stations (International Satellite Television Handbook, 1995). What this means in practical terms for the use of commercial earth stations in developing countries is that supply and demand are nearly equal. Therefore, if an organization wants to buy time using the existing earth station, there may not be enough time available, the cost of using the ground station may be too high, and/or you can run the risk of being bumped by a higher bidder. These constraints could impact the delivery schedule, e.g., classes could be canceled, and/or it may be too expensive to conduct the training because using the satellite is too costly<sup>3</sup>.

An alternative to commercial satellites, and the most viable option in developing countries, is to use stand-alone very small aperture terminals (VSAT). Leasing a VSAT provides the user with exclusive access and 24-hours of airtime. In addition VSAT uses time domain multiple access (TDMA), is modular, charges a flat rate, is portable, and is easily assembled.

The cost of a VSAT that provides bandwidth of 128 Kbps which is sufficient for the Desktop Video system is approximately \$6000/month. The cost of a VSAT that provides a bandwidth of 384 Kbps which is sufficient for the Group Video and Electronic Classroom systems is about \$10,000/month.

<sup>3</sup> It is anticipated that it will be possible to purchase satellite time at approximately \$300/hour in the near future

## COURSEWARE DESIGN AND DEVELOPMENT COSTS

### Introduction

Studies on the costs of distance learning often confine themselves to an analysis of the costs of the hardware used to deliver a program and the communications links. However, these costs are only part of the total cost of providing distance learning. An additional expense of an effective distance learning course or program is the cost of designing and developing the instruction that will be presented.

Studies have shown that distance learning courses typically require more extensive planning than required for platform instruction. Clark (1989) has stated that there are two technologies that contribute to effective distance education: the hardware technologies and the social science (instructional design) technologies. Haarland and Newby (1984) have stated that increases in student performance and satisfaction found in the research may be due to improved course design and teaching performance rather than to the attributes of a specific technology. Because course design and development plays such a crucial role in effective distance learning, information on these costs are needed by decision makers so they can make a fully informed decision about the cost of providing distance education.

The purpose of this section is to provide cost projection data for the design and development of two-way interactive distance learning courses. This section provides examples of approximate costs for producing distance learning courseware based on a military study that was conducted by several of the authors of this report. Included in this section is an overview of the requirements for effective design and development of distance learning courses, a cost model, a brief explanation of the variables in the model, and the course design and development costs for two hypothetical courses that differ in length and complexity.

These cost projections assume that design and development costs will not differ substantially by the choice of communications method or hardware. That is, the design and development costs for terrestrial-based communications are the same as those for satellite-based communications. Similarly, the design and development costs for presenting a course via a desktop video system will not differ significantly from a course presented by an electronic classroom system provided that the systems have the same basic instructional capabilities.

### Instructional Design for Distance Education

The instructional requirements for good distance learning courses are not substantially different from those required for stand-up or platform instruction. Both require sound instructional objectives, good presentation of the content, opportunities for students to interact with each other and with the instructor, effective instructional materials, good evaluation measures, etc. However, the fact that the instruction takes places when the student and the teacher are physically separate, means that more planning is typically required to insure that the instruction is effective.

Several course design features that are key to successful two-way interactive distance learning have been identified in the literature (Bailey, et al., 1989; Cyrs & Smith, 1990; Defense Language Institute, 1992; Ostendorf, 1991; Sheppard, et al., 1990):

- provision for group dynamics, specifically interaction among the students and between the students and the instructor

- carefully structured student involvement activities
- provision for corrective and confirming feedback
- short lecture segments (20-30 minutes)
- visual aids, such as graphics and video sequences, that have been adapted for two-way interactive distance learning
- an interactive study guide for the students

#### Source of the Cost Data

The cost projections presented here are based on the results of a military study conducted in 1992-1993 (Martin et al., 1994). Five courses were reconfigured from a platform format to two-way video teletraining using the Army's five-component Systems Approach to Training (SAT) model: Analysis, Design, Development, Implementation, and Evaluation. These five components formed the basis of the cost model.

The costs used in the military project were obtained by examining actual contractor and sub-contractor billings. Each item from the monthly billings was examined to determine whether it was a design or development cost. Design costs included costs associated with formulating the instruction, such as: writing objectives, designing test items and selecting media and instructional methods. Development costs included expenses related to preparing materials, such as: producing the graphics and writing the interactive student study guides and the instructors' course manuals.

#### Cost Model

The cost model used for the analysis was adapted by Martin et al. (1994) from Bramble and Bauer (1991). The cost model enabled the military project to determine the total cost of producing all five courses and the cost of producing a single course.

The cost model used in the military project was:

$$C_i = \sum_{j=1}^5 (AN_i + DE_i + DV_i + DL_i + EV_i + \text{sum}(SO_{ji})) = AD_i$$

The variables in this model are defined as follows:

- $C_i$  = the total cost of course "i"
- $AN_i$  = the cost of analyzing course "i"
- $DE_i$  = the cost of designing course "i"
- $DV_i$  = the cost of developing course "i"
- $DL_i$  = the cost of delivering course "i"

- $EV_i$  = the cost of evaluating course "i"
- $SO_{ji}$  = the cost of operating remote site "j" for course "i"
- $AD_i$  = the administrative costs associated with course "i".

For the purpose of the cost projections presented in this section of this report, only the costs for designing (DE) and developing (DV) the courses were analyzed. Therefore, the cost variables of analysis (AN), delivery (DL), evaluation (EV), and remote site operations (SO) are not included.

### Cost Projections

Using data from the military study, it was possible to project the cost of designing and developing two hypothetical courses: (a) a course that is eight hours in length and has approximately 250 graphics, and (b) a course that is approximately 80 hours in length with over 1,000 graphics. These course scenarios were selected to show cost differences in a relatively short course (one day) versus a relatively long course (two weeks).

This cost projection provides a range of costs from the least expensive to the most expensive course, based on actual cost data from five different courses. An average of the total costs is also presented. Again, this analysis does not include any course revision costs, costs related to the number of students, or the costs of operating the receiving site.<sup>4</sup>

The cost projections provides different numbers of visualize (e.g., graphics, pictures, illustrations, diagrams, etc.) because these are an important instructional component of two-way interactive video instruction (Cyrs & Smith, 1990). One drawback to using two-way interactive distance learning is that instructors often talk to the camera, i.e., they become a "talking head." This is a poor instructional use of the technology. Graphics can be used effectively to help explain and clarify content, and they are typically more motivating and interesting than the "talking head." Most instructional design recommendations for effective two-way video instruction include the use of a variety of graphics. Graphics are therefore an important variable in this cost analysis.

Short course The expected costs of an 8-hour course of instruction that contains approximately 250 graphics are shown in Table IV. Table V shows the expected costs of an 80-hour course of instruction that contains approximately 1100 graphics.

<sup>4</sup> Instruction delivered to non-English speaking countries will require translation. These costs are not included in the cost estimates.

**Table IV. Cost Projection for Design and Development of an Eight Hour Course**

Area	Range of Costs
Design, and develop (excluding graphics)	\$6,304.60 - \$11,753.52
Graphics	\$1,990.00 - \$3,115.00
Total Costs	\$8,294.60 - \$14,868.52
Average Cost	\$11,581.56

**Table V. Cost Projection for Designing and Developing an Eighty Hour Course**

Area	Range of Costs
Design, and develop (excluding graphics)	\$63,046.07 - \$117,535.43
Graphics	\$8,652.52 - \$13,544.02
Total Costs	\$129,727.80 - \$302,022.89
Average Cost	\$215,870.95

Although these courses were reconfigured from existing courses, an extensive course design and development effort was required. The average design and development cost for an 80 hour course was \$215,870.95; for an eight hour course the average cost was \$11,581.56. In fact, the course design and development costs accounted for more than one-third of the entire cost of implementing the military courses.

#### Video Production Costs

The military project cited above used commercially and locally produced videotapes to present some instruction. The locally produced videos were purchased as part of a package arrangement with one of the subcontractors. Hence, accurate per-hour costs could not be estimated.

A price quote from a commercial video production house provided the following costs for professional video production. These costs are charged for per day basic video shooting do not include any post-production services.<sup>5</sup>

<sup>5</sup> Mark One Images, P. O. Box 616705, Orlando, FL



• Videographer	\$275.00/day
• BetaCam rental	\$450.00/day
• Sound Assistant	\$250.00/day
• Lights	\$100.00/day
• Grip (technical asst.)	\$150.00/day
Total	\$1225.00/day

In addition, 1/2 hour BetaCam tapes for recording the instruction must be purchased at a cost of \$25.00 each. This results in an estimated per hour cost of approximately \$295.00.

#### Issues Related to Instructional Design and Development for Distance Education

The design and development costs for distance courses are expensive components of the overall costs of distance education. One remedy to this problem is to curtail or simplify the design and development process, thus reducing the overall costs of distance education. One idea is to provide instructors the opportunity to present instruction from homes, offices, or desks using the same materials that they use in non-distance education courses. These materials are then configured for distance education on a piecemeal basis during the instruction term rather than during an extensive pre-instructional development effort. This scenario works especially well with the desktop video system configuration because the equipment is relatively easy to use from an office and technical personnel are not required in order to deliver the instruction.

Another option with the more sophisticated equipment is to use technical personnel extensively, thereby relieving the instructor of those duties and allowing him or her to focus on reconfiguring the instructional materials *during the instructional term*. While this option may reduce the cost of instructional design for distance education, the cost of additional personnel (e.g., technicians) may again increase costs.

Another issue related to design and development costs is the frequency that a particular course is offered. If, for example, the same course is presented more than once, the design and development costs can be amortized over multiple course offerings. This means that the design and development costs need only to be incurred once. On the other hand, if it is intended that a course would be presented only once or twice, the design and development effort could be significantly scaled down, thus reducing overall costs. While it is impossible to determine precisely the cost reduction because the reduction would be dependent on the type of course offered, it could be expected that fewer media (e.g., graphics, videotapes) would be developed and the design of on-line and off-line activities would be simplified. All of these modifications would decrease the design and development costs.

At the present time, however, course design and development is an expensive component of the entire distance learning enterprise. The overall costs of conducting distance education can be reduced by reducing the costs of instructional design and development. If this can be accomplished without affecting the quality of instruction, this may be an effective way to reduce the costs of delivering distance education.

## CONCLUSIONS

The primary purpose of this paper was to provide a cost comparison of three different levels of two-way interactive distance learning systems for developing countries. Presented were hardware, communications, and instructional design and development costs. All three of these elements should be considered before beginning a distance education program. An optimal scenario for distance delivery is dependent upon the needs and priorities of the selected country, the infrastructure of country, the amount of money available to spend for hardware and communications, the requirements of the courses presented, and personnel experience and availability. Included below are three distance learning scenarios and their associated costs. These examples are provided for comparison, including a preferred scenario for developing countries.

The purpose of this section is to demonstrate the assembly of the cost information. Because there are three levels of two-way interactive distance learning system configurations (desktop video, group video, and electronic classroom) and varying levels of instructional design, several possible permutations of total cost are possible. This section demonstrates the process of combining the different cost factors to arrive at a particular system that can fulfill specific training and education needs.

### Examples

The cost examples presented in this section are representative for a course that is offered once. Both fixed and variable costs are included in the examples. Fixed costs include the hardware system and the first time instructional design and development costs. Successive offerings of the course would utilize the already existing hardware, and the instructional design and development costs would be limited to minor revisions, modifications, and updating the course. The reader is advised that these are startup costs. The costs per course offering will decrease significantly as the number of course offerings increases. Thus, the cost per course offering will be reduced drastically over time.

A typical photovoltaic (PV) course ranges between 18 and 30 hours. Of these hours, approximately 1/4 to 1/3 of the course consists of laboratory and group activities, i.e., hours conducted outside the classroom. Therefore, when presenting a PV course via a two-way interactive distance learning system, some of the total course hours would be presented off-line. For example, an 18-hour PV course would include at least 4 or 5 hours of instruction that would not be presented via distance learning. While this will provide a cost savings in terms of delivery, a professional or paraprofessional site coordinator would have to be present to assist with off-line activities. These personnel requirements are not included in the cost estimated below. Of the 13 remaining hours, instruction that could be standardized, e.g, lectures, examples of PV systems, demonstrations, could be presented by pre-taped videos; the rest of it by live two-way interactive distance learning.

Given this information, three PV course scenarios, each of which would be presented during a one-month period, are presented below with their associated costs. There is one origination and seven receive sites in each scenario. The following formula was used:

Total Costs = H (hardware) + C (communications) + ID (instructional design and development).

Course 1: This is an 18-hour PV course presented via a desktop video system at 128 kbps. The instructional hours consist of the following:

4 hours conducted off-line

5 hours of pre-taped video

9 hours of live, interactive instruction with less than 250 graphics

The total cost for this scenario can be broken out as follows:

Hardware	\$139,100.00
Communications	\$ 6,000.00
Instructional Design (pre-taped videos)	\$ 1,475.00
Courseware and Graphics	\$ 11,582.00
<b>Total Cost</b>	<b>\$158,157.00</b>

Course 2: This is an 18-hour PV course presented via a group video system at T1/4. The instructional hours consist of:

4 hours conducted off-line

5 hours of pre-taped video

9 hours of interactive instruction with 1000+ graphics

The total cost for this scenario can be broken out as follows:

Hardware	\$561,000.00
Communications	\$ 10,000.00
Instructional Design (pre-taped videos)	\$ 1,475.00
Courseware and Graphics	\$ 8,653.00
<b>Total Cost</b>	<b>\$581,128.00</b>

Course 3: This is an 18-hour PV course presented via an electronic classroom at T1/4. The instructional hours consist of:

4 hours conducted off-line

5 hours of pre-taped video

9 hours of live, interactive instruction with 1000+ graphics

The total cost for this scenario can be broken out as follows:

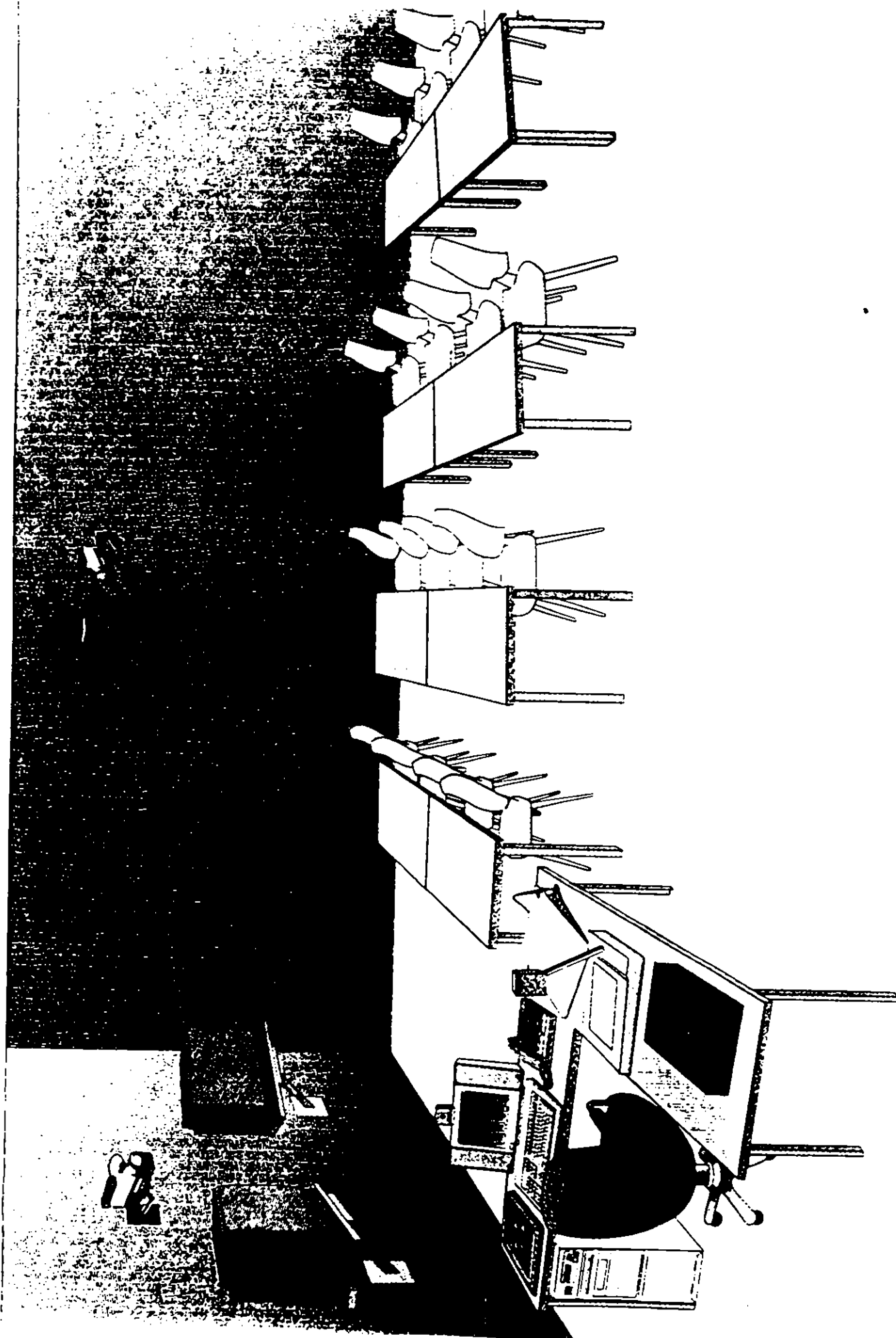
Hardware	\$960,000.00
Communications	\$ 10,000.00
Instructional Design (pre-taped videos)	\$ 1,475.00
Courseware and Graphics	\$ 8,653.00
<b>Total Cost</b>	<b>\$980,128.00</b>

#### Preferred Delivery Scenario for a PV Course for Developing Countries

Based on the above discussion, the preferred delivery system is the one described for Course 1 above. This scenario is preferred because continued improvements in telecommunications and computer technologies will allow for higher fidelity desktop systems at relatively lower costs. This option presents the most favorable tradeoff between cost and instructional effectiveness and capability.

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## Appendix D

# **RURAL ELECTRIFICATION, ENVIRONMENTAL REMEDIATION, AND ECONOMIC DEVELOPMENT IN LATIN AMERICA AND AFRICA**

**Concept Paper  
November 1995**

## **Introduction**

A consortium representing one or more countries in Latin America and/or Africa, the U.S. government, industry, and academic institutions is considering submitting a joint proposal to the World Bank and/or other multilateral financial institutions to address critical needs in developing countries. These needs include:

- Rural electrification
- Environmental remediation and control
- Clean, potable water supply
- Improved health care in rural clinics
- Economic development, including job creation, new markets for renewable energy products and services, increased productivity and financing.

The need for electric power in the developing world is significant. Over 2 billion people worldwide do not have electric power. The per capita energy consumption in many areas is one-fortieth of the average consumption in the U.S. Electric power in rural areas is often non-existent or unreliable. To be more productive and to raise their standard of living, developing countries must increase their production and distribution of energy. The increased demand for electric power production capacity in developing countries is estimated at 5 million megawatts over the next 30 to 40 years!

Fossil-generated electricity creates serious emission problems, especially carbon emissions affecting global weather. Clean, renewable energy systems and conservation offer the best solutions for meeting much of the world's energy demand without severely impacting the environment. For developing countries, infrastructure must be established to facilitate marketing, distribution and support of the renewable energy products that can significantly improve conditions.

## **The World Bank's Solar Initiative**

In March 1995, the World Bank announced its new *Solar Initiative*, an effort to work with its member countries, the energy industry, research institutes, and non-governmental organizations (NGOs) to hasten commercialization of solar and other renewable energy technologies and to



expand their applications significantly in developing countries. The initiative has two main thrusts:

- Preparation and finance of commercial and near-commercial applications
- Facilitation of international research, development and demonstration (RD&D).

In addition, the Global Environment Facility (GEF), a branch of the World Bank, provides grants and concessional funds to developing countries for projects and activities that aim to protect the global environment. The GEF can "buy down" the high capital costs of near-commercial renewable energy technologies to meet the World Bank's investment criteria. Sources of financing that can be leveraged by the GEF include conventional development finance from the multilateral development banks, the International Finance Corporation, commercial financing sources, private direct investment, direct investment of utilities, and various combinations.

Technologies in which the World Bank is interested include photovoltaics, wind, solar thermal, and biomass gasification. Financial resources to prepare projects involving these technologies (typically 1 to 3 percent of the total project costs) may be available from a variety of sources, including multilateral investment banks, UNDP, bilateral grant aid, private investors, electric utilities, and the developing countries themselves.

### **Project Concept**

The consortium proposes a project that will:

- Build on an existing rural electrification project involving the installation of a large number of photovoltaic, wind, and/or biomass gasification systems
- Seriously address the need for infrastructure development to ensure the long-term success of the project
- Uniquely combine advanced communications, instructional, and renewable energy technologies for satellite-based distance training and education
- Develop markets and private sector business opportunities for independent power producers and energy service providers
- Provide unprecedented access to technical and marketing databases for new businesses in developing countries
- Electrify rural homes, schools, health clinics, village centers, businesses and other value-added applications using clean, renewable energy
- Reduce carbon emissions
- Monitor and control remote energy systems using satellite-based supervisory control and data acquisition (SCADA).

### **Goal**

The overall goal of the project is to enhance the quality of life in one or more of the targeted

countries through rural electrification and sustaining infrastructures. The project's intent is to empower the local populace with the tools necessary to meet their present and future needs. These tools include not only electricity-producing hardware, but also renewable energy services, financing opportunities, training, education, and access to information and data -- in short, all those services necessary to effectively support the long-term successful operation of rural electric power systems.

### **Renewable Energy Hardware for Rural Electrification**

Rural electrification involves both renewable energy hardware and supporting infrastructures. Rather than developing an entirely new project, an attempt will be made to identify and build upon an existing hardware applications project. Such a project should include a large number of photovoltaic, wind, and/or biomass systems for producing electricity. The types of applications of interest include:

- Lighting, radio, television and communications for homes and buildings to increase literacy, social activities, and productivity
- Electric water pumps and purification systems for potable water supply to reduce infant mortality and improve health
- Vaccine refrigeration, ventilation, purification and communication equipment for rural health clinics to reduce infant mortality and improve health care and diagnostics
- Lighting, communications, computer and other equipment to support small businesses
- Lighting, computers, educational technology and communication equipment for schools
- Ventilation, lighting and other equipment for increased productivity of poultry farms
- Small appliances and battery charging for a variety of applications
- Lighting, communications, refrigeration, battery charging, radio and television for village centers
- Ice production and other value-added application for fishing and food service industries.

### **Infrastructure Development**

Many past renewable energy hardware application projects for developing countries have had high failure rates because of a lack of supporting infrastructures. Rural electrification requires at least two key industries: independent power producers and energy service providers. For products such as photovoltaic and wind systems, it is unlikely that manufacturing will occur in many of the developing countries, although it is certainly encouraged if financing is available. Local manufacturing of other balance-of-system components will be strongly encouraged. More commonly, the in-country infrastructure for these industries will include financing, marketing, distribution, design, installation, inspection, maintenance, repair, and other post-installation services. Training, education and continuous infusion of data and technological advancements are important for building and sustaining strong infrastructure. Design assistance, procurement assistance, and access to databases (which until now were generally unavailable) are services that can and should support infrastructure development.

## **Education and Training**

Education and training are key elements in developing and enhancing the energy, environmental and other infrastructures necessary to meet the basic human needs in these countries.

Because of the lack of terrestrial communication services in the developing world, a satellite-based communication link is required. A well designed satellite-based distance education and training program can: a) reach larger audiences, b) enhance learning, c) provide greater consistency in delivery, d) lower costs per student and e) provide a continuous link between learners and subject matter experts. Strong emphasis will be placed on technology-enhanced education, including digital and asynchronous communications, computer networking, and shared software.

## **Databases**

The following databases, previously unavailable, are being developed and will be made available to project participants and small businesses in the targeted countries:

- Solar insolation data
- Industry directories and product directories
- Photovoltaic module performance ratings based on Florida Solar Energy Center (FSEC) test results
- Battery and charge controller performance based on FSEC test results
- System and component test and evaluation reports
- Accepted design practices and guides
- Lighting system performance and ratings based on FSEC test results
- Recommended procurement specifications for lighting, water pumping and refrigeration systems
- Solar thermal collector test results and energy ratings.

## **Target Locations**

To identify one or more developing countries as clients for the World Bank and major participants in the proposed project, the following criteria were developed:

- Existing or imminent renewable energy application projects
- Energy resources and needs
- Existing education and training infrastructure
- Supporting institutions
- Existing satellite earth stations that can be used for project management and education and training activities
- Prospects for political and financial support.

Based on the above criteria, over twenty countries in Latin America and Africa have been identified as potential participants. Of these, two countries in Latin America are of special interest: Ecuador and Colombia. Presently Georgetown University is providing small business development assistance to these countries, and NASA has satellite earth stations in both Quito and Bogota that are linked to the U.S. via the Advanced Communications Technology Satellite (ACTS). Brazil, Argentina and Kenya are also strong candidates for participation.

### **Possible Participants and Roles**

Targeted countries:	Ecuador, Colombia, Brazil, Argentina, Kenya and/or other Latin American and African countries with identified needs for rural electrification; will submit proposal, request financing and promote economic development
FSEC/IST/UCF:	Operator of U.S. Photovoltaic Southeast Regional Experiment Station since 1982; leader in photovoltaic test, evaluation and system design; energy and environmental courses; instructional design and development; energy databases; design assistance; project coordination
NASA LeRC:	ACTS link; use of earth stations; communications expertise
Georgetown Univ:	Experienced in small business development and assistance using satellite-based distance education in Ecuador and Colombia; international needs assessment; identifying cooperating institutions in developing countries; policy, planning, and small business development
Brevard Comm Coll:	Leader in distance learning; Electronic University Network/AOL; training of support personnel; two-year academic programs
Enersol Associates:	NGO; significant experience in international applications and training
NCSC/NCSUS:	Energy systems expertise; education and training; distance education facilities; international program involvement
Orion Energy:	SCADA and renewable energy systems engineering; software development
RETI/U.S. ECRE:	Alternative energy industry support and subject matter experts; international program involvement
Savannah State Coll:	Training and academic courses for Africa; Center for Advanced Water Technology and Energy Systems
Siemens Solar:	Largest photovoltaic module manufacturer in world with outstanding training capability; training courses, materials and hardware

### **Possible U.S. Government Participants/Advisors**

NREL:	Expertise and databases in renewable energy resources, materials, components and systems; international program involvement
Sandia Nat'l Labs:	Expertise and databases in renewable energy components and systems; international program involvement

## **Possible Equipment and Service Providers**

AT&T:	Multipoint video conferencing; global communications; Center of Excellence in Distance Learning; language services
Global Datalink:	Internet solutions and training; asynchronous communications; wide area networking; facilities development
Hughes:	Satellite link (Spaceway)
Intelsat:	Satellite link to Africa
PictureTel:	Multipoint video conferencing equipment and global communication services

## **Budget and Duration**

Much more planning will be required before reliable and appropriate pricing information is available. However, a total budget of \$20 to \$30 million is anticipated for a three-phase, ten-year program. Phase I would involve hardware installation, training, infrastructure development, facilities development, and pilot testing for the balance of the lifetime of the Advanced Communications Technology Satellite (i.e., about three years). Phase II would involve additional hardware installation, market development, new satellite links, and expansion of education and training course offerings (three to four years). Phase III would involve some hardware installation, greater market development, training for energy service providers plus complete academic program offerings (i.e., 2-year, 2+2, and graduate degree programs). \$10 to \$12 million would be required for facilities, equipment, and earth stations.

## **Contact Person**

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## Appendix E

**Course Manual Outline  
and  
Corresponding Video Tapes**

Section	Tape	Title	Time	Instructor
1	1	Introduction and Overview	1 hr.	Ventre
2	2	Solar Radiation	1 hr.	Ventre
2A	3	Electrical Fundamentals	1 hr.	Dunlop
3	4	Photovoltaic Effect and Materials	1 hr.	Dhere
3	5	Photovoltaic Effect and Materials	1 hr.	Dhere
4	6	Modules, Panels and Arrays	1 hr.	Dunlop
4	7	Modules, Panels and Arrays ( <i>Lab 2: Load I-V Measurements: Matching Loads &amp; PV Modules/Arrays</i> )	1 hr.	Dunlop
5		<b>Photovoltaic System Components</b>		
5	8	P.S.C.: <i>System configurations and BOS</i>	1 hr.	Dunlop
5	9	P.S.C.: <i>Batteries</i>	1 hr.	Dunlop
5	10	P.S.C.: <i>Batteries</i>	1 hr.	Dunlop
5	11	P.S.C.: <i>Charge Controllers</i>	1 hr.	Swamy
5	12	P.S.C.: <i>Lab 5: Charge Controllers</i>	1 hr.	Swamy
6		<b>System Sizing Procedures</b>		
6	13	System Sizing Procedures	1 hr.	Demi
6	14	System Sizing Procedures	1 hr.	Demi
6	15	System Sizing Procedures	45 min.	Demi
6	16	SSP: <i>System Sizing Demonstration: NSOL</i>	1 hr.	Swamy
6	17	SSP: <i>PV Water Pumping</i>	1 hr.	Dunlop
6	18	SSP: <i>Sizing PV Water Pumping Systems</i>	1 hr.	Dunlop
6	19	SSP: <i>PV Water Purification Case Study</i>	1 hr.	Demi
7		<b>PV System Electrical Design</b>		
7	20	PV System Electrical Design	1 hr.	Dunlop
7	21	PV System Electrical Design	1 hr.	Dunlop
7	22	PV S.E.D.: Circuit Drawings and Schematics	1 hr.	Demi
7	23	PV S.E.D.: Circuit Drawings and Schematics	1 hr.	Demi
8		<b>Mechanical Design and Building Integration in italics)</b>		
8	24	Mechanical Design and Building Integration	1 hr.	Ventre
8	25	MD&BI: <i>Technical Specifications (A Case Study)</i>	1 hr.	Ventre
8	26	MD&BI: <i>Lab 7: System Assembly and Checkout</i>	1 hr.	Demi

<b>Section</b>	<b>Tape</b>	<b>Title</b>	<b>Time</b>	<b>Instructor</b>
9	27	Maintenance and Troubleshooting	1 hr.	Demi
10	28	Economic Analysis	1 hr.	Ventre
10A	29	PV Lighting Systems	1 hr.	Dunlop
11	30	Utility Interconnection Considerations and Course Summary	1 hr.	Ventre



## Appendix F

# **ACTS FOR DISTANCE EDUCATION IN DEVELOPING COUNTRIES**

## **Research Agenda**

### **Use of Shared Software in Video-teletraining (VTT)**

- What are the advantages and disadvantages from the delivering instructor's perspective?
- What is the impact on course design, development time and costs?
- What is the impact on course scheduling and pacing?
- What types of software offer unique and significant advantages from the learner's perspective?
- What do students most like and most dislike about the use of shared software?
- How many students per computer/work station can effectively use shared software?
- Are learning gains influenced by the inclusion of shared software in the courseware?
- What are the primary uses/benefits of shared software in VTT (e.g., for practice, explanation/demonstration, testing applications)?

### **Effectiveness of Desktop Video in Distance Learning**

- How important is frame rate, resolution, and overall video quality to learning for various types of software?
- What are the tradeoffs (economic, video quality, audio quality, etc.) between analog and digital video systems?
- What are the tradeoffs between window sharing and conventional networking?
- What are the advantages and disadvantages of having shared software resident on desktop video systems at both delivering and receiving sites?
- What are appropriate ratios of students to desktop video systems for effective utilization of the technology?
- What are the advantages and disadvantages from the delivering instructor's perspective?
- What do students most like and dislike about using desktop video for instruction?

- What interfacing standards are most appropriate for accommodating future growth and change?
- What other support equipment is desirable for effective delivery (e.g., digital tablet, document camera, etc.)?

### **Appeal and Acceptance of Desktop Video Systems from the Instructor and Students' Perspectives**

- Were/are the instructors enthusiastic to about using desktop video? shared software?
- Were/are students enthusiastic to about using desktop video? shared Software?
- Do instructors and students prefer this method of instruction to others they have tried?
- If given the chance, would instructors and students use desktop video in other courses? shared software?
- How does physical separation affect those of desktop video, if at all? shared software?

### **Effects of Network Size on Distance Learning**

- What is the maximum number of receive sites that can be used and still allow interaction and mastery of the course objectives?
- What are the maximum numbers of students at a receive site and in the overall network that can be educated/trained without degradation in the learning process?
- What are the maximum number of desktop video systems that can be connected to a single MCU?
- What are reasonable cycle times to switch between all receive sites?
- What are recommended switching methods to promote audio and/or video interaction?

### **Marketing Distance Education in Developing Countries**

- What are the needs/benefits and funding sources for distance education in foreign countries?
- What elements are needed to provide good distance education?
- What courses would be most valuable or needed? How long should they last? What are the optimum instructional and communications technologies to use?

- Is there a market for Cadillac (e.g., ACTS) capabilities or is the Chevy version better?

### **Cost Benefit Analyses**

- What are the cutoff points for cost effectiveness and course length? What is the breakeven point, payback period, etc.?
- Is there a cost that is economically viable for staff training, student fees, etc? Is there a reasonable charge per student?
- What are the course development/conversion time requirements and costs (per student hour, per course hour)?
- What are the instructional delivery time requirements and costs (per student hour, per course hour)?
- What are the technical support costs before, during and after course delivery?
- What are the costs of using different media options?

### **Novelty Effects**

- How strong is the novelty effect? How does it influence learning? How does one assess novelty effects?
- How can course interest be sustained?
- What are the educational effects of technology? How can they be measured?

### **Technological Complexity and User Response**

- How easy is the distance learning equipment to use? How long does it take to learn to use it (and other media) by instructors, site facilitators, and support personnel?
- How much of the 1.544 Mbps pipeline is needed?
- What are the barriers to acceptance by instructors, site facilitators, support personnel, and students?

### **Effectiveness of Media by Task Type**

- What are the multimedia capabilities using ACTS? What is the best video display technology (e.g., size of monitors, number of monitors, video overlays, software sharing)?

- What future multimedia technologies (trends) should NASA investigate?
- Is there a preferred format for delivery of instruction?

### **Foreign Expertise/Cultural Issues**

- Is there expertise to run a distance education program/system in foreign countries? Should courses only be offered in major metropolitan areas? Is it economically feasible?
- How long does it take foreign instructors and staff to develop content knowledge and equipment expertise?
- What is needed to support training in foreign countries? What are the best training approaches?
- What computers and communications technologies are available and suited for foreign countries? Is multi-point transmission viable?

### **Importance of Satellite Technical Features**

- How important are high frequencies and large bandwidths?
- How important are high, medium, and low video compression rates in terms of learning benefits?
- What are the time lags when transmitting from site to site?
- What are the hardware and technical limitations on the number of possible receive sites (satellite or other)?

### **Effectiveness of Course Design Options**

- How much and what type of interactivity is necessary? How does it affect learning? How often does it need to occur?
- What is the optimum lesson pacing? How much on-line vs. off-line time is best?
- How often should learning be assessed?
- What is the best approach to providing feedback for both learners and instructors? How often should it be provided? What technologies are best suited for this purpose?
- What is the optimum number of receive sites? What is the optimum number of students per site?

### **Instructor Effectiveness/Student Achievement**

- Do students master the lesson content? What are student attitudes concerning the effectiveness of the instruction?
- How effective is the instructor using the instructional technologies, media, and ACTS equipment (ease of use)?
- How adaptable is the instructor to using the equipment?

## Appendices

- A. Literature Search: Review Documents
- B. Report entitled, *A Cost Comparison of Alternative Approaches to Two-Way Interactive Distance Learning in Developing Countries.*
- C. Origination/Receive Sites
- D. Paper entitled, *Rural Electrification Environmental Remediation and Economic Development in Latin America and Africa.*
- E. Course Manual Outline and Corresponding Video Tapes
- F. Research Agenda